Large-scale Modeling of Bioenergy Mandates under Volatile Crop Yields

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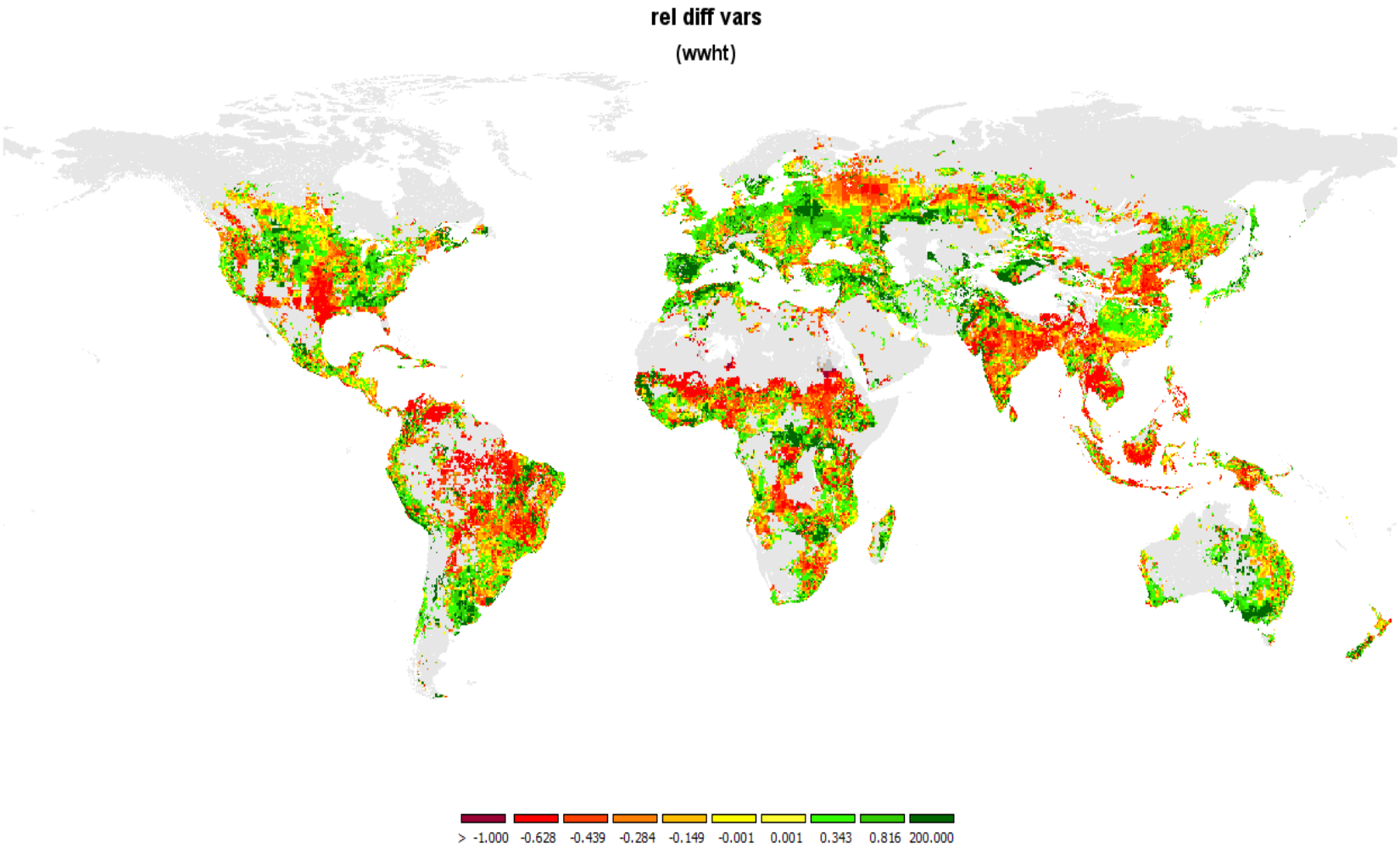
Background

- Volatility of crop yields
  - Bioenergy Mandates
  - Food security concerns
  - Impact on prices, environment

- Analysis so far largely deterministic
  - Uncertainty taken into account through scenario analysis
  - Scenarios appropriate to explore ranges of outcomes
  - Decisions taken **under** uncertainty different from those formed on the basis of complete information



Relative Difference in Variances (2050/2100) in Wheat Yields

[Data: Tyndall, Afi Scenario]

Research Questions

- Promotion of biofuels
  - Climate change mitigation (e.g. in the European Union)
  - Consolidation of energy security (e.g. in the US)
- BUT: additional pressure on land
  - Competition with efforts to store more carbon by decreasing deforestation rates
  - Diversion of food crops into the production of bio-fuels as a reason for increased food price volatility
  - Wright (2010): US/EU bio-fuel mandates contributing to food price spikes
- Two channels to dampen this:
  - Storage
  - "Option agreements with domestic biofuel producers" to ensure diversion of grain to human consumption during food shortages

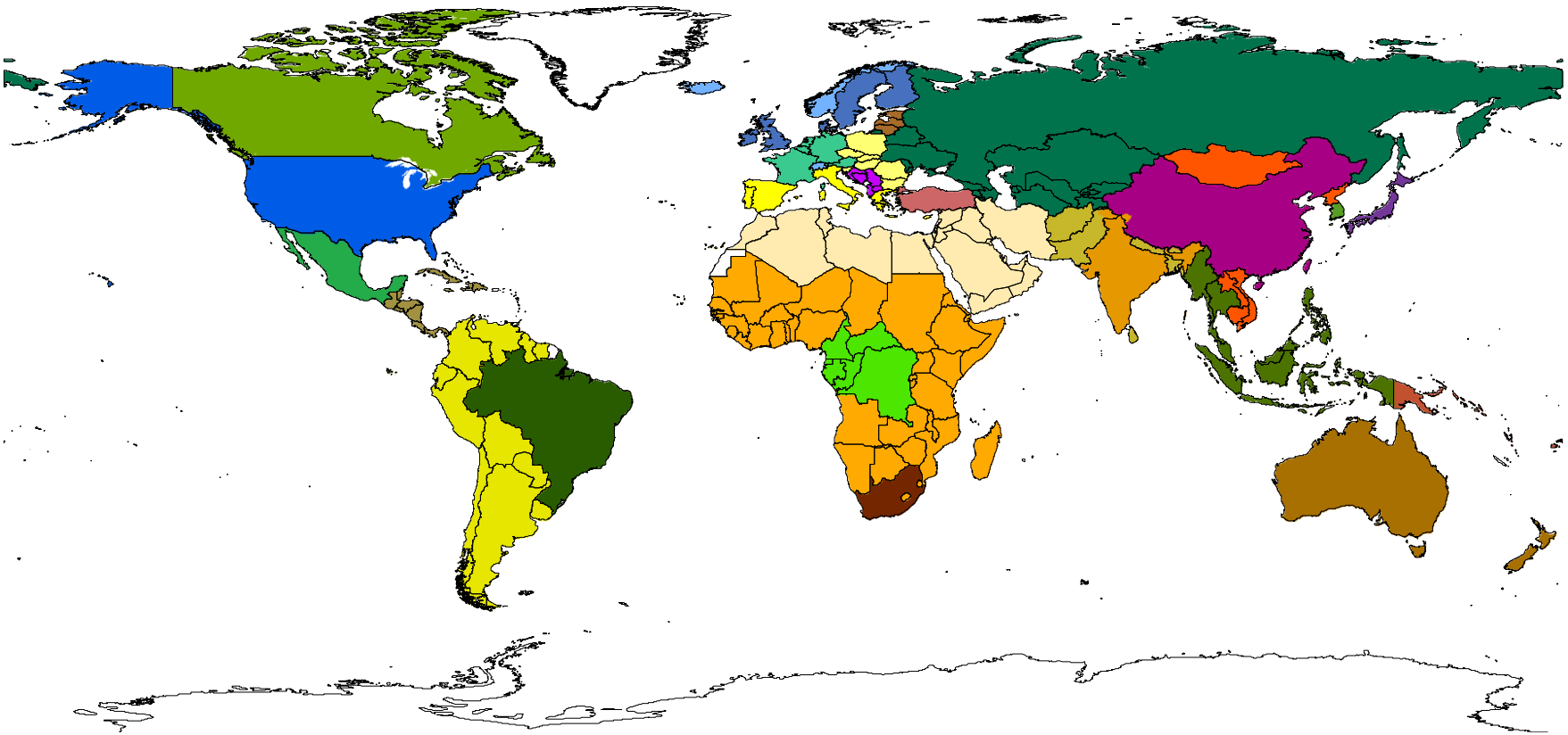
Overview

- Brief overview of the Global Biosphere Management Model (GLOBIOM) , www.globiom.org
- Stochastic version of GLOBIOM
- Scenarios
- Results

Global Biosphere Management Model

Coverage: the Earth

Basic resolution: 28 regions



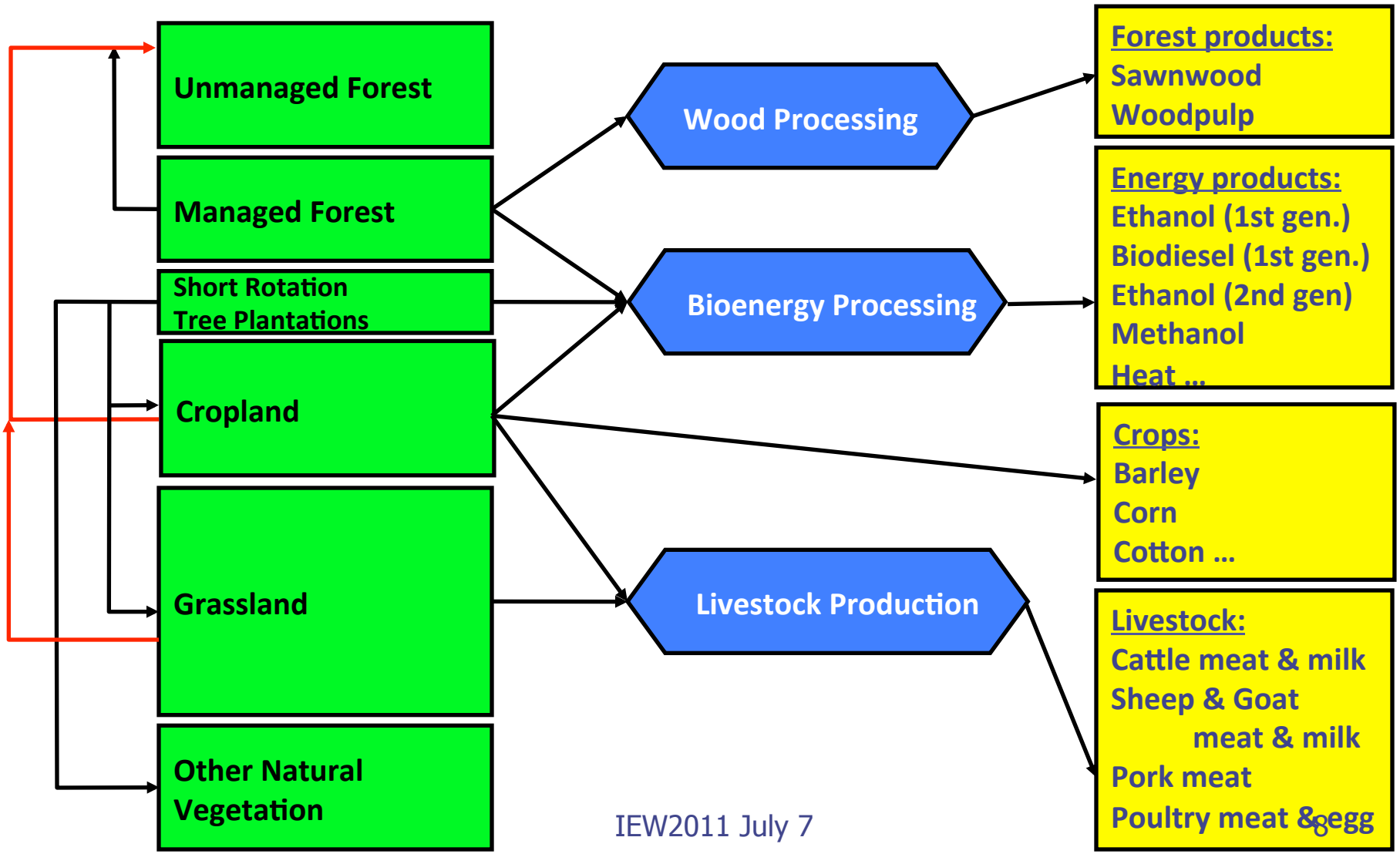
Three Land-based Sectors

Forestry: traditional forests for sawnwood, and pulp and paper production

Agriculture: major agricultural crops and livestock products

Bioenergy: conventional crops and dedicated forest plantations

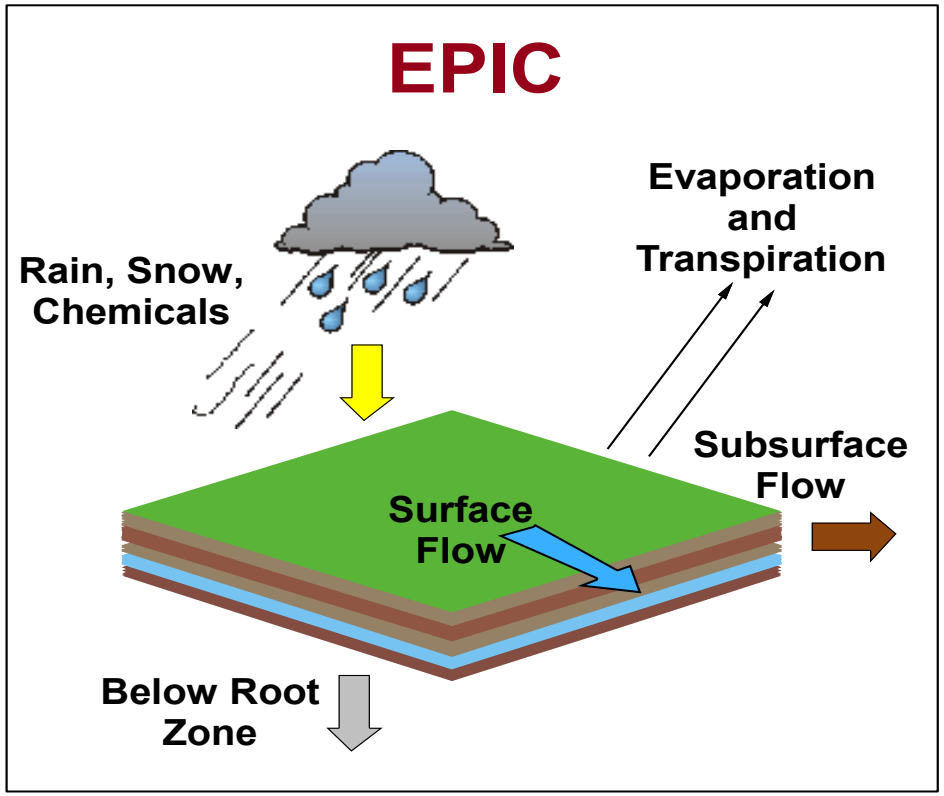
Supply Chains



Cropland - EPIC

Processes

- Weather
- Hydrology
- Erosion
- Carbon sequestration
- Crop growth
- Crop rotations
- Fertilization
- Tillage
- Irrigation
- Drainage
- Pesticide
- Grazing
- Manure



Major outputs:

- ✓ Crop yields, environmental effects (e.g. soil carbon)
- ✓ 20 crops (>75% of harvested area)
- ✓ 4 management systems: High input, Low input, Irrigated, Subsistence

Optimization Model (FASOM structure)

- Recursive dynamic spatial partial equilibrium model
- Partial equilibrium model: endogenous prices
- Maximization of the social welfare (PS + CS)

Drivers and Output

Main exogenous drivers:

Population (IIASA projections)

Diets (FAO, 2006)

Bio-energy demand (POLES team, JRC Seville, WEO)

(GDP, technological change,…)

Output:

production Q → land use, water use, GHG, environment

consumption Q

trade flows

prices

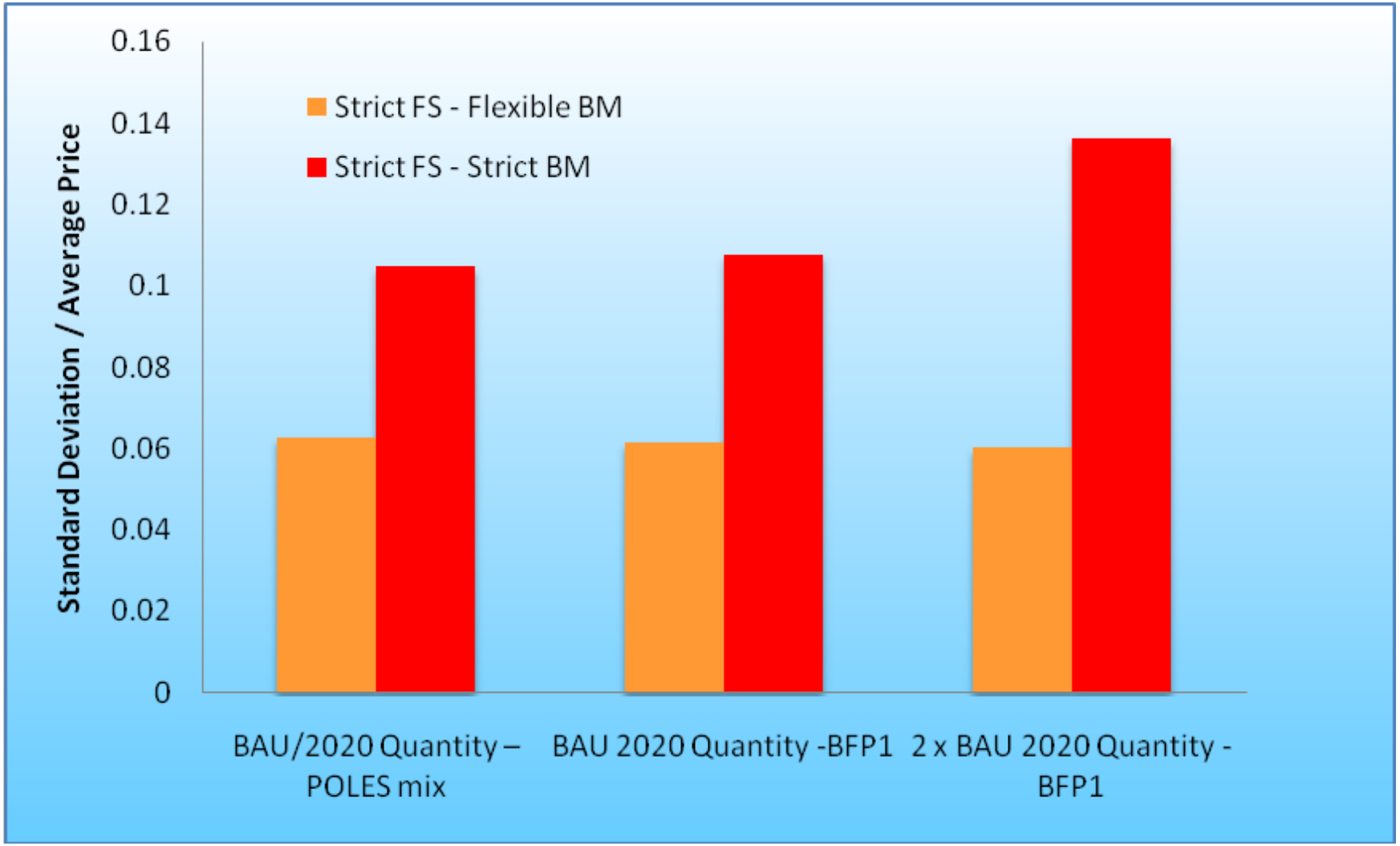
GLOBIOM-S 1.0

- Changes in the deterministic model
  - State-dependent primal variables in the model are – supply, "final food demand", trade flows (adjusting to realization of a state).
  - Realize trade flows etc upon realization of a state (of yield) in the future.
- Stochasticity
  - Crop yield variability estimated from historical yields (FAO 1961-2006). Means and co-variance matrix → yield distributions (100 per crop/region)
- Objective function
  - State-dependent variables' expected value
  - Attitude towards risk: safety-first constraint

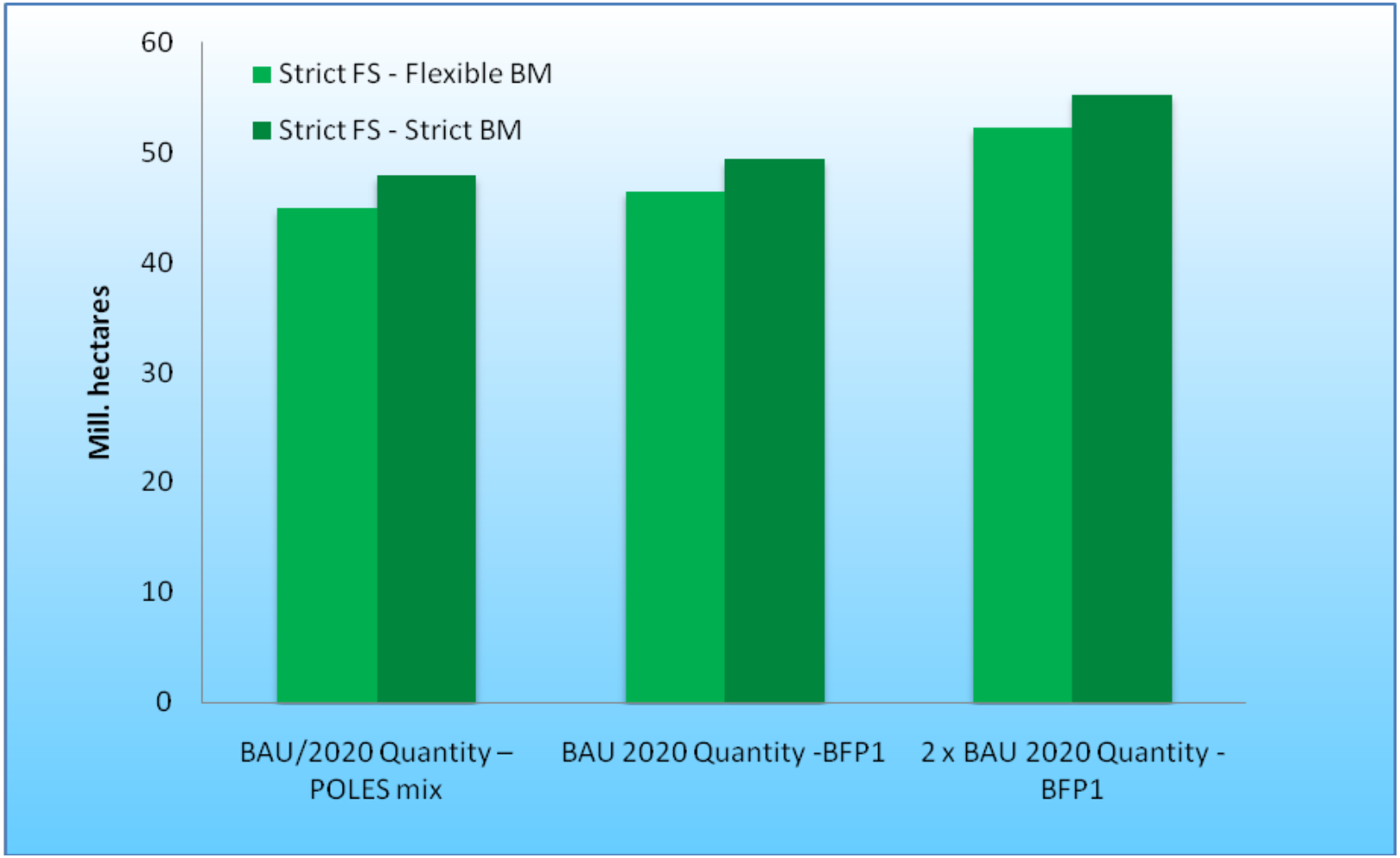
Scenarios

- Gradually more ambitious Bioenergy Mandate (BM)
- Strict Food Security (FS) constraint
- Strict versus flexible BM enforcement

Price Volatility



Environmental Implications: Deforestation



Conclusions

- Inflexible bioenergy mandates
  - Food price volatility
  - Food security under fluctuating yields
  - Deforestation

- Value added of stochastic model
  - Model runs using flexible mandates principally equivalent to those from a deterministic model using average yields
  - Results are very different from the runs with strict mandates

Work in progress

- More sources of uncertainty: climate change, cost of adaptation options, ...

- Physical storage capacity vs. biofuel production

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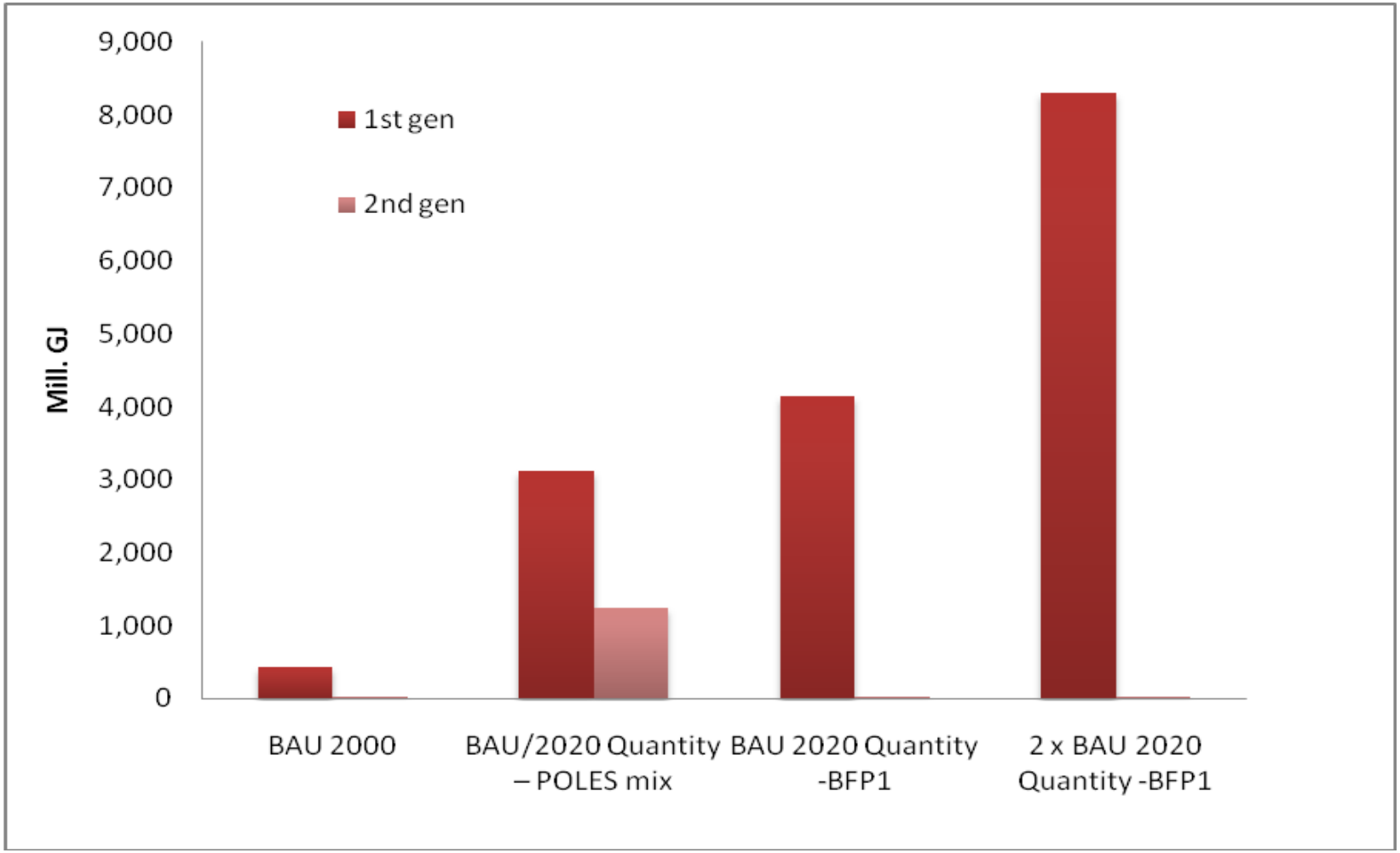
Bioenergy Mandates



Source: Russ et al. (2007), JRC Reference Reports, JRC-IPTS, Seville, Spain.